Design and Testing Impact Attenuator of Formula SAE FG17 Garuda UNY Car

by Z Arifin

Submission date: 10-Aug-2020 12:19PM (UTC+0700)
Submission ID: 1367943043
File name: Arifin_2019_J._Phys.__Conf._Ser._1387_012091.pdf (696.15K)
Word count: 2741
Character count: 14105

Design and Testing Impact Attenuator of Formula SAE FG17 Garuda UNY Car

Design and Testing Impact Attenuator of Formula SAE FG17 Garuda UNY Car

Z Arifin[1], S Gunawan[1]
[1]Dept. Automotive Engineering, Engineering Faculty,Universitas Negeri Yogyakarta

Abstract. This research aimed to find out the design and testing of Impact Attenuator (IA) on the Formula SAE FG17 Garuda UNY (as the development of learning materials in Materials Engineering course). The method used in this research is using research and development model (R & D). Product development model used ADIIE development model (Analysis, Design, Development, Implementation, and Evaluating). Based on the result of impact attenuator test with dimension length 220 mm, width 250 mm, height 250 mm and using 1 mm aluminum plate material in Abaqus software, it can be seen that the result of "Total Energy of The output set" on the test 7777724 mJ at 0.0325 s. Furthermore, based on the results of the impact attenuator test using UTM tool, capable of absorbing energy of 7722.25 Joule, Peak deceleration on impact attenuator specimens is 28.212 g's, Average deceleration in this impact attenuator specimen is 15.908 g's, The shape change on anti-intrusion plate test is 21.4 mm. From the test result, the Impact attenuator fulfills the 2017 Formula SAE (T3.20 Impact Attenuator) regulation.

1. Introduction

Student Formula Japan (SFJ) is a competition held annually by the Japanese Society of Automotive Engineers (JSAE) which competes 2 categories including static event and dynamic event. Tecnical inspection is a race that falls into the category of static event competitions which aims to inspect the suitability of vehicles for regulation [1]. Technical inspection includes general inspection, noise test, tilt test, and brake test. General inspection is an examination of the suitability of all vehicle components against regulations, ranging from general design requirements, driver's cell, cockpit, drive equipment (belt and cockpit padding), general chassis rules, brake systems, powertrain, fasteners, vehicle identification, structural equivalency spreadsheets, impact attenuator data report, standard impact attenuator, and bulthead fronts and main roll hoop support for example configurations[2].

Impact attenuator is a component that must be present in Formula SAE vehicles. Impact attenuator is a device that is able to change shape (deformation) and absorb energy. Impact attenuator is attached to the front of the vehicle and attached to the front frame (front bulkhead) which serves to reduce the impact energy on the main frame of the vehicle during a collision. Impact attenuator must be able to absorb a minimum energy of 7380 Joules with a maximum average deceleration of 20 g's and a maximum peak deceleration of 40 gs [3]. Therefore, the selection of impact attenuator materials and the construction of the impact attenuator greatly affects the results of testing the impact attenuator. On FG16 vehicles, the impact attenuator used can absorb energy of 8898,847 Joules, with average deceleration of 10.8 g's and peak decelration at 16.4 g's. The higher the high energy that can be

absorbed by the impact attenuator the better. The ability of the impact attenuator in the average deceleration and peak deceleration can be increased again, so that the impact when the vehicle crashes can be even safer. This is a challenge for the team to be able to develop an impact attenuator. The FG16 vehicle using the material used for the manufacture of impact attenuator is an aluminum plate with a thickness of 1 mm and an anti intrussion plate used that is made from aluminum with a thickness of 6 mm. By using such material, the FG16 vehicle impact attenuator has disadvantages, among others: the weight of a very heavy impact attenuator material which is 1.77 kg and a very large impact attenuator surface area of 60,000 mm2[4].

2. Method

The method used in this study is to use the research and development (R & D) model. Analysis, design, and material development and construction of the FG17 impact attenuator, were carried out in the Garuda UNY Team Basecamp. Having his address at Base camp Garuda UNY Team. The FG17 impact attenuator test specimen was made at the Garuda UNY Team workshop. Attenuator impact testing is carried out by the Quasi-static test method, conducted at GadjahMada University, Laboratory of Material Technology. The development procedure used to produce the Impact Attenuator product on the FG17 Garuda UNY Team vehicle adapts to the ADDIE development model described as follows:

2.1 Analysis

The analysis activity was carried out through Formula SAE 2017 regulatory study activities and literacy studies needed to produce impact attenuators. Starting from the dimensions of the impact attenuator and supporting parts (front bulkhead& Anti intrusion plate), requirements or testing procedures are required, and the test results required. And the second literacy analysis needs to make impact attenuators, such as Materials, Construction, product production methods, and testing impact attenuators [5].

2.2 Design

This stage is known as development of conceptual, material selection, manufacture impact attenuators and the advantages & disadvantages of these materials. The next construction, in the design of products made by considering the regulatory requirements of Formula SAE. Construction on the impact attenuator is one of the things that greatly affects the energy that can be absorbed when the vehicle collides. Therefore the construction material data is taken from several related books and theses related to the impact attenuator[6].

The last manufacturing produce, and the difficulties / ease of making impact attenuator products. This is very important to discuss because in the real field not all materials used are not easy to obtain in the field and even at the production stage researchers must be able to design products according to the ability of skill makers and funding capabilities.

2.3 Development

he stage is realization of what has been designed in the design. This development phase includes (a) manufacturing by software abaqus the impact attenuator is fixed on the rear surface and will be hit with a beam weighing 300 kg at a speed of 7 m / s and (b) analysis the results will get the "Total Energy of the output set" in the test. And these results will be analyzed and compared with the regulations of Formula SAE 2017.

2.4 Implementation

The implementation phase is carried out after the product at the development stage is deemed feasible to be made real product. At this stage everything that has been developed is installed or made in real accordance with its role or function. then the researcher will discuss about making impact attenuator products in detail and clearly. The production of products in real form aims to test the impact attenuator product using a universal testing machine.

2.5 Evaluation

Evaluation is done to find out the results of product testing that has been developed. At this stage the impact attenuator product will be tested using a universal testing machine. Evaluation results can be used as an analysis material for the comparison process between testing using software and actual testing using a universal testing machine. After the product is tested, then the test results will be processed using equations which have been explained in the study of the theory above. The final step is to compare the results of the impact attenuator test using a universal testing machine with the regulation of Formula SAE 2017.

After testing using the Abaqus software, the results will be "Total Energy of the output set". The test results will be analyzed and will be compared with the regulation of Formula SAE. To facilitate reading, the test results will be displayed on tables and graphs.

The second test is testing specimen impact attenuator using a universal testing machine. The data obtained are "changes in the shape of the impact attenuator" (in mm) and "impact force" After doing the feeding test the test results will be processed and calculated to determine the absorbed energy and deceleration in the impact attenuator. The test results data will be processed and calculated using equations that have been explained in the theoretical study. To facilitate reading, the test results will be displayed on tables and graphs. Then the data will be compared with the regulation of Formula SAE 2017.

3. Results and Discussion

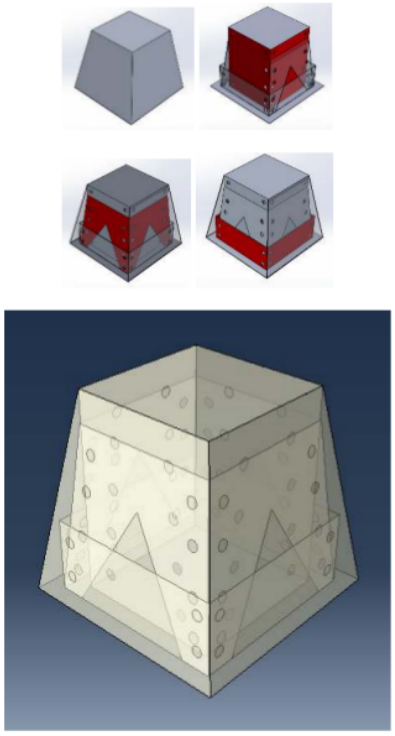

Figure 1. Design construction IA FG17

In this study there are 2 results of testing the impact attenuator product, the first test using abaqus software at the implementation stage. Testing of the impact attenuator specimen was carried out on July 10, 2017. Tests were carried out by 3 students from the Garuda UNY Team and 5 Advidsor Garuda UNY Team members. With the following results

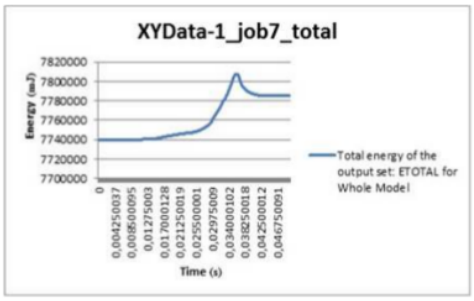

Figure 2. Total energy of the output set

The results of the data from the impact attenuator test with abaqus software are attached to figure 4. Energy absorption works stably and continues to increase until it reaches a maximum energy absorption of 7777724 mJ at 0.0325 s. Although the test time is up to 0.05 s, the maximum damage to the impact attenuator occurs at 0.0325 s, marked by a change in color on the test beam at 0.035 s. The results of this test are not known to result in avarage deceleration and peak deceleration because the first step is to find out by knowing the force acting on the impact attenuator, according to the formula obtained from the committee if the force acting on the impact attenuator is calculated (m) in each energy absorption. But in this test only known energy absorption and testing time.

The second test data is impact attenuator testing data using Universal Testing Machine (UTM). The results of the test data on the impact attenuator specimen are attached to attachment 2. The initial force acting on the impact attenuator is 0.5 kN at a displacement of 0.001 m. Style works stably and continues to increase until it reaches a maximum force of 83 kN at a displacement of 0.165 m. the level of damage or deformation of the anti intrussion plate is 21.4 mm.

The results of the force received by the impact attenuator specimens at each displacement can be seen in Figure 5. The force displacement graphs that work on the impact attenuator specimens can be seen in the figure below.

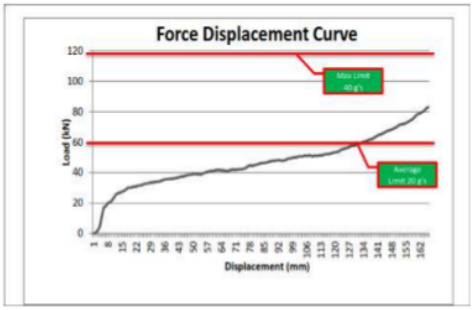

Figure 3. Force displacement testing result impact attenuator

To find out the energy results that can be absorbed by the impact attenuator can be known by the following equation:

With the magnitude of force F = 0.5 kN and displacement S = 0.001 m. the business can be determined (the energy transferred) E is:

E = 0.5 kN x 1000 x 1 mm / 1000

E = 0.5 Joule

The results of calculating the energy absorbed by the impact attenuator specimens at each displacement can be seen in Figure 6. The graph of the energy absorbed from the test results of the impact attenuator specimen can be seen in the picture below.

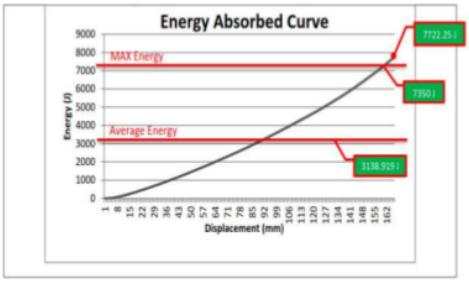

Figure 4. Energy absorbed spesimen impact attenuator

To find out the average deceleration and silver deceleration can use the equation formula as follows:

$$A : \frac{F}{m.g}$$

With the magnitude of force F = 83000 N, mass m (assumed as vehicle weight) = 300 Kg, and gravity g = 9.81 m / s2, deceleration can be determined (g's) is:

Peak Deceleration $= \frac{83000}{300\,x\,9{,}80665} = \mathbf{28,212}\boldsymbol{g's}$

Peak deceleration in the impact attenuator specimen is 28,212 gs. To find out the avarage deceleration by summing all decelerations in each test table then divided by a number of test tables. The average deceleration in this specimen is 15.908 gs. Here are the calculations:

Total deceleration = 2624,835 g's
Amont of deceleration data = 165
Average Deceleration = 2624,835/ 165 = 15,908 g's

The deformation that occurs on the anti intrussion plate after testing the impact attenuator is 21.4 mm. Furthermore, the damage that occurs in the impact attenuator before until after the test is 165 mm. And the size of the impact attenuator after testing is 75 mm.Based on the tests carried out, the maximum energy yield can be absorbed by the impact attenuator specimen in testing using a universal testing machine of 7722.25 Joule at a displacement of 0.165 m. The absorbed energy value meets the regulations determined by the committee, which is a minimum of 7350 Joules. Furthermore, Peak deseleration in the impact attenuator specimen is 28.212 gs, this has met the regulation of the SAE Formula (T3.20 Impact Attenuator), which is a maximum deceleration value of 40 g's. And for the Average deceleration on impact attenuator specimens is 15.908 gs, this has met the regulation of the SAE Formula (T3.20 Impact Attenuator), which is a maximum with decelerations of an average of 20 g's. The shape change in this testing anti-intrussion plate is 21.4 mm, the change in shape of the anti intrussion plate has met the regulation of Formula SAE (T3.20 Impact Attenuator), which is a maximum deformation of 25 mm. Just like testing using the Abaqus software, basically it can be even greater if the impact attenuator plate does not occur a lot of large indentations at the time of the deformation, this happens because of the lack of strong aluminum plate impact attenuator. The conclusion of this test is that the impact attenuator meets the regulation of Formula SAE 2017 (T3.20 Impact Attenuator).

4. Conclusions

Based on the research and discussion that has been done, conclusions can be taken as follows:Results of the design and development of the FG17 impact attenuator, simulation of the impact attenuator test in the Abaqus software produced an energy absorption of 7777724 mJ at 0.0325 s.The results of testing the FG17 impact attenuator. Energy Results were absorbed in the impact attenuator test of 7722.25 Joules. The results of the impact attenuator test, as follows: Peak deceleration: 28,212 g's, Average deceleration: 15,908's. The result of Anti intrussion plate deformation in the impact attenuator test is 21.4 mm.

5. References

[1] Belingardi G and Obradovic J 2010 Design of the impact attenuator for a formula student racing car: numerical simulation of the impact crash test *Journal of the Serbian Society for Computational Mechanics* **4** 52-65

[2] Williams T, de Pennington A and Barton D 2000 The frontal impact response of a spaceframe chassis sportscar *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering* **214** 865-73

[3] Rising D, Kane J, Vernon N, Adkins J, Hoff C and Brelin-Fornari J 2006 Analysis of a frontal impact of a Formula SAE vehicle. SAE Technical Paper)

[4] Branch R M 2009 *Instructional design: The ADDIE approach* vol 722: Springer Science & Business Media)

[5] Zarei H and Kröger M 2008 Optimum honeycomb filled crash absorber design *Materials & Design* **29** 193-204

[6] Obradovic J, Boria S and Belingardi G 2012 Lightweight design and crash analysis of composite frontal impact energy absorbing structures *Composite Structures* **94** 423-30

6. Acknowledgments

Special thanks to Garuda UNY Racing team who has supporting to developed FG17 and Head of Laboratory Of Material TechnologyUniversitasGadjahMada, forthe testing of impact attenuator.

Design and Testing Impact Attenuator of Formula SAE FG17 Garuda UNY Car

ORIGINALITY REPORT

15%	13%	11%	15%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Negeri Manado Student Paper	5%
2	Submitted to University of Greenwich Student Paper	2%
3	cometa.ues.rs.ba Internet Source	2%
4	eprints.unm.ac.id Internet Source	1%
5	ijens.org Internet Source	1%
6	Abinav Shankar Siva Balan, Ashok Bragadeshwaran, Gowutham Eswaramoorthy, Arun Pandiyan Rajendran, Vemuluri Ramesh Babu. "Vehicle Side Safety Enhancement through Door Intrusion Barrier Analysis and Recuperation", SAE International, 2019 Publication	1%
7	Simonetta Boria. "Design Solutions to Improve	

	CFRP Crash-Box Impact Efficiency for Racing Applications", Wiley, 2013 Publication	1%
8	Submitted to University of Wales Swansea Student Paper	1%
9	Submitted to Kingston University Student Paper	1%
10	Reza Afshar, Aidy Ali, B B Sahari, M Bayat. "Axial Crush of the Tubular Structure with Various Cee-Shaped Cross-Sections", IOP Conference Series: Materials Science and Engineering, 2011 Publication	1%

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	Off		

Design and Testing Impact Attenuator of Formula SAE FG17 Garuda UNY Car

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7